Optimizing Algebraic Thinking in Elementary Students: Exploring the Impact of Generative Learning

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Abstract

This research aims to optimize algebraic thinking in elementary school students through the application of a generative learning model. The research approach uses an experimental method with a post-test-only design. The research was conducted on grade V students of SD Negeri Kalisari 03, which consisted of 64 students from two classes which were then divided into 2 groups, namely the experimental class and the control class. Data analysis was carried out with descriptive and inferential statistics, with the help of SPSS, first a prerequisite test was carried out, namely a normality test and a homogeneity test, and the hypothesis of this research was carried out using the two-track variance analysis (ANOVA) method. The results of the study showed an increase by obtaining a significance value of less than 0.05 with a mean square of 476,190. This means that the KBA of students who learn using the Generative model is better compared to students who learn using the Expository model. The application of the generative learning model can improve students' algebraic thinking skills in two indicators of algebraic thinking ability, namely: generalizing the arithmetic pattern of a problem and understanding mathematical modeling from the four indicators used in this study.

Keywords: Algebraic Thinking, Generative Learning, Primary School.

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INTRODUCTION

Mathematics as a core subject is taught at all levels of education and is more than just number manipulation (Reys, 2009). In addition, Mathematics also involves aspects of thinking, functions as a universal language, has elements of art, and is a tool that has applications that are closely related to everyday life. This idea is in line with the Principles of the National Council of Teachers of Mathematics (NCTM, 2000) which underlines the purpose of learning mathematics for students is to develop and enhance their understanding of mathematical concepts and relationships as they construct, compare, and apply various representations.

Advances in technology have increasingly emphasized the importance of mathematics in everyday and professional life. However, many people still have difficulty in understanding mathematics due to the complexity of its structure, teaching methods, and difficulty in understanding especially in elementary schools

(Mutlu, 2019). Previous research conducted by Hanum (2017) stated that mathematics learning at the elementary school level is an interesting topic to discuss. This is due to the mismatch between the characteristics of the cognitive development of children at primary school age, which are concrete, and the abstract characteristics of mathematics itself. In this context, it is important to discuss the importance of mathematical ability in basic education and the impact of mathematics learning difficulties on students' daily lives and future careers (Selvianiresa & Prabawanto, 2017).

Furthermore, Hanum (2017) suggests that often the suitability of mathematical structures with the stages of children's cognitive development becomes a challenge, which requires educators to look for innovative approaches to improve students' understanding of mathematical concepts. Encouraging students' active participation in the maths learning process can also play a key role as a key element in strengthening the quality of their understanding of mathematical concepts and procedures. This approach should be supported by active and task-learning environments that develop thinking and problem-solving skills (Litster et al., 2020). Student involvement in learning will affect student ability, in line with the idea Romberg (1990) that identifies that students only gain strong understanding when actively involved in building their own understanding. Schliemann et al., (2013) revealed that elementary school students can use variable notation to describe functional relationships. The improvement of algebra skills is influenced by a variety of factors including instruction that suits the needs of students. In line with this idea, Arcavi (2005) revealed the importance of developing symbolic understanding in algebra learning in schools by providing supportive teaching methods. In accordance with the opinion of Steele & Johanning (2004) the period of algebraic thinking refers to the period of recognizing and analyzing mathematical structures, understanding and identifying mathematical relationships, making generalizations, and analyzing changes.

Algebraic thinking has an important role in mathematical thinking and problem-solving and is best developed from an early age (Lenz, 2022; Sibgatullin et al., 2022; Wettergren, 2022) algebraic thinking in elementary schools is seen as a way to reduce the difficulties students face when they are faced with formal algebra lessons in school and secondary schools (Somasundram, 2021). National Assessment Data for 2022, which is a program from the Ministry of Education, Culture, Research, and Technology (Ministry of Education and Culture, 2023) at the elementary school education level of grade V students on a national scale, the ability to count is in the medium category, which is 46.67% and has increased by 16.1 from 2021 (30.66%). In addition, the results of observations were made on elementary school students in East Jakarta at SD Negeri Kalisari 03. Teachers say that most grade V students still have difficulties including: 1) difficulty in identifying mathematical patterns and relationships between numbers or objects; 2) Difficulty in using symbols Algebra does not understand that symbols can be used to represent unknown numbers or variables in a problem.

Addressing the problem of understanding algebraic concepts in elementary school students, in line with the results of research conducted by Pratiwi et al. (2017) shows that the ability to think algebra in elementary school students in Indonesia tends to be low. In addition, this study categorizes obstacles in algebraic thinking into three types, namely ontogenic barriers, didactic barriers, and epistemological barriers. Alternatively, Store (2018) argues that introducing concepts of algebraic thinking at the elementary school level can be an effective first step in understanding algebra. In this context, the development of algebraic thinking is also influenced by factors such as the mathematical disposition of students, belief in effort and talent, and belief in the existence of a single truth, as mentioned by (Wettergren, 2022). To overcome the problem of low algebraic thinking skills in elementary schools, an approach that is able to overcome these problems is needed, one of which is the application of learning models that facilitate the learning process to be more active. The learning model that researchers will apply is a generative model, a learning process with a student-centered generative model.

The generative learning model focuses on considering students' previous learning experiences and understandings so that the learner can actively generate meaningful connections between previous knowledge and new information (Grabowski, 2003). The generative learning model according to Kyle et al. (1989) is a combination of previous knowledge with new information consisting of four stages, namely: 1) Introduction; 2) focus; 3) challenge, and; 4) application.

This model has been used in learning and successfully overcoming errors in students, one of which is research by Kusairi et al. (2020) showing that there is an influence of the Generative learning model on solving mathematical problems and mathematical creative thinking skills, as well as the application of generative learning models with worksheets of elementary school students better than conventional learning models. So, this research is to find out the influence of the Generative Learning model on the algebraic thinking ability of elementary school students.

RESEARCH METHOD

This study adopts an experimental method, which according to Shadish et al. (2002), study in which the intervention is deliberately applied to observe its impact. This study focuses on the elementary school population in Pasar Rebo sub-district, with the sample selected using the probability sampling method and the Cluster Random Sampling technique. According to Rogers and Révész, (2019) the Cluster Random Sampling technique involves two main stages. First, the overall population is organized into groups or clusters, which are often based on geographic areas or districts such as villages, schools, neighborhoods, or blocks. Then, these clusters are randomly selected, and all individuals in the selected clusters are included in the sample. In this study, after the randomization process was carried out, SD Negeri Kalisari 03 was chosen as the research location, with the number of students in class V as many as 64 students. One class was chosen as an experimental group that would receive generative learning, while the other class became a control group with conventional learning. The instrument used is an algebraic thinking ability test given after Posttest. This instrument is designed to measure students' initial understanding and progress in algebraic thinking. The research data was obtained through an algebraic thinking ability test instrument. The indicators in this study include symbolic reasoning skills in the mathematical modeling process, generalizing patterns, making problem-solving predictions, and presenting problem-solving strategies.

The researcher uses data analysis techniques in the form of descriptive and inferential statistics, with the help of SPSS for inferential statistical testing. Before drawing conclusions through hypothesis tests, analysis prerequisite tests are first carried out, namely normality tests and homogeneity tests. The hypothesis test in this study was carried out using the two-way variance analysis (ANOVA) method. According to Campbell et al. (1963) the two-way ANOVA is designed to assess the relationship between two classification variables, each with two or more levels, and the outcome variable.

RESULTS AND DISCUSSION

The data of the research results were obtained from the results of the students' algebraic thinking ability test given after the treatment, the following are the results of the algebraic thinking ability test of students who used the generative model and the Expository model:

Table 1. Results of the Average Calculation of the Algebraic Thinking Ability Test (KBA)

Learning Model	Max Test Score	Average	
		KBA Test Scores	SD
Generatif	95	72,67	12,82
Ekspository	86	67,90	8,0

From Table 1, it is known that the average KBA score of students who study with the Generative model is 72.67, higher than students who study using the Expository model which obtained an average score of 67.90. This shows that the application of the Generative model tends to be more effective than the Expository model.

Before conducting hypothesis testing the analysis requirements test is carried out before conducting an inferential analysis. Hypothesis testing in parametric statistics requires that the data is normal and homogeneous. The normality test of the overall data was carried out using Kolmogorov-Smirnov and in each group using Shapiro-Wilk. The following are the results of the normality and homogeneity test of the data.

Table 2. Results of the Normality Test Calculation

Data Type	Group	Statistics	Df	Sig's score	H0
Combination	Learning Model	0.090	84	0.089	Receive

Table 3. Homogeneity Test Calculation Results

Data Type	Levene Statistic	Df1	Df2	Sig's score	H0
Algebraic Thinking Ability Test	0,974	3	80	0,409	Receive

Based on Table 2, a significance score of more than 0.05 (significance level) was obtained both in the group data and in the overall data, so the research data was normally distributed. In addition, in Table 3, it can be seen that overall, the research data has homogeneous variances. Furthermore, the inferential statistical test can be carried out by parametric statistical test using Anava Two Ways and the calculation results.

Table 4. Hypothesis Test Calculation Results

Source	Type III Sum of Squares	df	Mean Square	Sig.
Corrected Model	6757.810a	3	2252.603	0.000
Intercept	414966.857	1	414966.8571	0.000
A	476.190	1	476.190	0.001

Table 4. Presenting the results that the learning model obtained a significance value of less than 0.05 with a mean square of 476.190 until H0 was subtracted. This means that the KBA of students who learn using the Generative model is better compared to students who learn using the Expository model. Therefore, it can be concluded that the Generative model has a significant influence compared to the Expository model on student KBA.

Differences in Algebraic Thinking Skills Between Students Learning Through Generative Models Compared to Students Learning Through Expository K Models

The Algebraic Thinking Ability (KBA) of students who learn through the application of the Generative model is higher than the expository model. This finding is in line with the research of Kusairi et al. (2020) showing that there is an influence of the Generative learning model on mathematical problem solving and mathematical creative thinking skills, and the application of the generative learning model with elementary school students' worksheets is better than the conventional learning model. Similar findings the results of a study by Mumtaz et al. (2023) found that the use of generative learning models in experimental classrooms had a significant impact on improving critical thinking skills.

Students who learn with the Generative learning model have the ability to understand arithmetic patterns which has an impact on improving one of the indicators of algebraic thinking, namely generalizing the arithmetic patterns of a problem. Students find it easier to understand the material and practice questions when presented in the form of graphic representations such as a flat triangle. This representation can help students in better visualizing flat shapes and understanding the characteristics, properties, and relationships between the parts of flat shapes. This process occurs in the first stage, namely orientation. According to the opinion Mainali (2021) which states that Representation is an important element for mathematics teaching and learning because the use of various modes of representation will improve mathematics teaching and learning.

In addition, students have the ability to use symbols in mathematical modeling which is an indicator of algebraic thinking. Students better understand mathematical modeling when given an approach through keyword recognition in studying the area of a rectangle. Teachers provide examples from everyday life, such as desks and whiteboards, that help students see the relevance and usefulness of the concept. This process takes place in the second stage of the Generative model, namely focusing on ideas. In line with the idea of Kokkonen and Schalk (2021) using a concrete model is very useful in teaching mathematical concepts. Learning not only focuses on concepts, theories, and facts but also emphasizes more on application in daily life.

While students who learn with an expository model, the ability to understand patterns is not optimally formed and has an impact on the low ability to generalize arithmetic patterns of a problem which is an indicator of algebraic thinking. The lack of opportunities to develop ideas and the minimal learning process involves the role of students in understanding concepts by building ideas based on their life experiences. This learning process occurs in the 1st stage, namely concept introduction. These findings are in line with Schoenfeld (2022) statement which revealed that difficulties in understanding mathematics occur due to the complexity of its structure, less relevant teaching methods, and lack of student involvement in learning, especially in elementary schools.

Similarly, students' ability to use symbols in mathematical modeling, which is an indicator of algebraic thinking, is less developed. Students are not facilitated to exchange ideas and find solutions to the problems they face in a way that they better understand. This process occurs in the second stage of the expository model, namely working with concrete materials, the teacher provides explanations that are more relevant to the student's lives, in addition to setting rules in solving the problems presented. These findings are in line with Owens et al. (2020) that Dissatisfaction with active learning classrooms may also reflect the quality of the techniques applied. This can lead students to be confused about why they are involved in certain activities, which ultimately results in feelings of frustration.

CONCLUSION

The application of the generative learning model can improve students' algebraic thinking skills in two indicators of algebraic thinking ability, namely: generalizing the arithmetic pattern of a problem and understanding mathematical modeling from the four indicators used in this study. Through the application of generative models, it is able to stimulate critical thinking, creativity, and deep understanding of concepts. This success emphasizes the importance of actively engaging students in learning to achieve a higher level of ability in handling complex mathematical concepts such as arithmetic patterns. The implication is that generative learning can be a solid foundation in the development of thinking skills and the application of mathematical concepts to everyday life situations.

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